Understanding Effects of Climate Change on Water Resources in the upper Colorado River Basin: Assessments for the USGS Climate Effects Network

The USGS Climate Effects Network (CEN) is a new "network of networks" that will foster and coordinate interdisciplinary monitoring and research designed to identify and track key processes controlling resource and ecosystem response to climate change. As an initial phase of CEN planning, assessments of critical resources are being performed in several large watersheds of the nation to determine their vulnerability to climate change.

One area of particular concern pertains to water resources in the southwestern U.S. This area receives most of its water from the Upper Colorado River, which provides water for 27 million people and 3 million acres of farmland in 7 western states. This resource is increasingly vulnerable to climate change; recent trends of increasing air temperatures and decreasing precipitation are projected to continue, further stressing an already over allocated water supply system. The USGS is working with Federal and State agencies, academia, and private organizations on key water resource issues in the upper Colorado River Basin (UCRB) to document their current status and project future responses to climate change. Brief syntheses of several issues are provided below.

Changes in snowmelt timing in Colorado

Over 80% of precipitation in the Upper Colorado River Basin (UCRB) falls as snow and is stored in seasonal snowpacks, which serve as a large natural reservoir, providing water for drinking, agriculture, and industry throughout the west. Recently, scientists with the USGS, NOAA, and universities have documented significant changes in the timing of snowpack melt and associated spring runoff in the western U.S. In the UCRB, snowmelt and spring runoff have shifted towards earlier in the year by 2 to 3 weeks since the late 1970s. Even the cold, high-elevation snowpacks in Colorado, which were thought to be relatively immune to climate change, are now melting 2 weeks earlier than they did in the late 1970s. A USGS study indicated that in Colorado, the changes in snowmelt timing are strongly correlated with increasing springtime air temperatures, decreasing snowpack water content, and increasing dust concentrations in the snowpack.

Results from these studies imply that the natural snowpack reservoir is emptying much earlier in the season than in the past. Water managers and the public will need to consider ways to mitigate these changes. Possible actions include improving water conservation, reducing disturbance to fragile desert soils that are major sources of dust, and increasing manmade storage.

Quantifying sublimation from snowpacks in the UCRB

Sublimation involves the transfer of water from a solid state in the snowpack to a vapor state in the atmosphere. Unlike snowmelt, which is the other main process involving loss of water from the snowpack, it does not contribute to runoff. In the UCRB, sublimation may have a large effect on water supply. In 2004, for example, runoff was much less than anticipated in many areas of Colorado despite a near-normal snowpack; there was speculation that warm, windy weather during spring caused substantial losses from the snowpack due to sublimation.

The USGS is conducting a study to quantify sublimation in the UCRB and adjacent upper Platte River basin. Spatially-distributed estimates of sublimation will be made for the study area at 400 m resolution

using SnowModel. Sublimation also will be measured at 4 sites using Bowen-ratio systems, allowing verification of modeled sublimation estimates. These data will help scientists and water resource managers better understand spatial patterns in sublimation, and will result in better estimates of runoff available for drinking water, agriculture, and industry.

Effects of Mountain Pine Beetle on Water Resources in the UCRB

The mountain pine beetle is devastating lodgepole forests in the upper Colorado River basin (UCRB). Although the mountain pine beetle is a native insect, several factors have contributed to the current epidemic: increasing air temperatures, recent drought, and the presence of contiguous stands of mature, dense forest. Trees are now dead and dying throughout over 2 million acres of Colorado's forests. USGS scientists are collaborating with the USDA Forest Service, National Park Service, state and local government agencies, and universities on coordinated, interdisciplinary research to characterize impacts of this large-scale forest mortality on water resources in the UCRB. Examples of ongoing research projects include evaluations of (1) changes in nutrient and carbon loading to

drinking water supplies; (2) potential increases in forest fires and their associated water quality impacts; and (3) changes in snowmelt runoff timing and amount.

Results from these studies will enable water resource managers to plan for and adapt to anticipated changes in the amount and quality of water available for consumptive use that may be caused by the mountain pine beetle epidemic.